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EFFECT OF FOLIAR SPRAY OF NUTRIENTS ON GROWTH AND YIELD OF SPRING FODDER MAIZE UNDER SALINE CONDITIONS

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SUMMARY

Soil salinity and poor quality ground water are fast emerging major problems in India. The saline soils are generally inherently poor in nutrient content and applied nutrients are fixed in soil. It reduces their availability. Therefore, a field experiment was conducted during spring 2023 and 2024 to evaluate the effect of foliar application of nutrients on growth and yield of maize under saline ecosystem. Foliar application of 0.5% $ZnSO_4$ and 3% NPK (19:19:19) at 45 days after sowing produced significantly taller plants, highest biomass per plant, dry weight per plant and green fodder yield as compared to control. The green fodder yield under this treatment (476 q/ha) was ~12% higher than control. This treatment also recorded maximum gross return (86910 Rs/ha), net return (23857 Rs/ha) and B:C (1.38).

Key words: Fodder maize, zinc sulphate, NPK, foliar spray, fodder yield and economics

Globally maize ranked third among food grain crop sown on an area of 187.9 million hectare (Mha) (FAOSTAT, 2022). It is widely known as "queen of cereals" due to higher yield and versatility. It is staple food for more than 200 million people globally (FAOSTAT, 2022). Its demand is expected to double by 2050 in emerging economies (Rosegrant and Team, 2012). In India, it is the 3rd most important cereal grown on 9.63 Mha area and its share in national food grain production is ~9% (Singh, 2018). It is energy efficient, has low water requirement and short crop duration which makes it suitable for crop diversification in Trans IGP (Jat *et al.,* 2020). Besides human consumption, it is used as poultry feed, fodder and as industrial raw material.

India has the world's largest livestock population and is the largest milk producer globally. However, the country faces a persistent gap between fodder demand and availability, which is one of the major constraints to improving livestock productivity. India has over 535 million livestock animals, creating enormous demand for feed and fodder resources (Kushwah, 2025). The increasing demand for milk, meat, and other livestock products is putting additional pressure on fodder availability. Only about 4–5% of the total cultivated area is devoted to fodder crops. The area under fodder cultivation is around 9 Mha, which is insufficient to meet livestock requirements.

India requires about 827 million tonnes of green fodder, while availability is about 734 million tonnes, resulting in a substantial shortage (ICAR-IGFRI, 2013). At present, India faces a net deficit of 35.6% green fodder, 10.95% dry crop residues and 44% concentrate feeds (ICAR-IGFRI, 2013). One reason for fodder deficit is climate change, droughts, and salinity problems. In Haryana, fodder production can be increased by its cultivation on saline and degraded lands and integration of fodder crops into existing cropping systems.

In India, salt affected area extends to approximately 6.7 Mha. The salt-affected area in Haryana is about 0.31 Mha (Mandal, 2016). The total salt-affected soil in Rohtak and Jhajjar districts of Haryana is more than one lakh ha. Further, these two districts have groundwater quality (moderate to very poor) and water-logged area of about 3.5 and 1.9 lakh ha, respectively, indicating an increased extent of soil salinity in the irrigated areas. The un-favorable chemical environment due to high pH, soluble alkalinity in salt-affected soils suffers from wasteful transformation of applied N (Sundha *et al.*, 2017) and reduces symbiotic N fixation (Bharadwaj and Abrol, 1978). Sole application of gypsum creates disturbance on availability of soil P to plant because of insoluble Ca-P formation (Nayak *et al.*, 2013). The foliar application of NPK can be an option under salt-affected soils. The salt-affected soils inherently contain low Zn; further fixation of applied Zn occur due to formation of less soluble minerals such as franklinite ($ZnFe_2O_4$) or sphalerite (ZnS) in sodic soils when cultivated with rice crop under submergence (Swarup, 1985). Therefore, foliar application of Zn can be an alternative under saline environment.

In Haryana, 37% of groundwater is of good quality, 8% of marginal and 55% of poor quality. Among the poor-quality waters 18% were sodic, 11% were saline and 26% were saline-sodic (Mandal, 2024). It was widely reported that salinity stress reduces the availability of nutrients (Fe, K, Mn, Mg, P and Zn) in roots and shoots. Salinity stress decreases the root hair density and root hair length which collectively reduces root surface area. Less root surface area results in lower nutrient uptake (Robin *et al.*, 2016). The plant survival during germination and emergence is the most important indicator of salinity tolerance (Saadat and Homaee, 2015).

Waterlogging in low lying areas due to rainfall delayed or sometimes prevented the sowing of *rabi* crops in certain parts of Haryana. In these areas, spring maize can be a suitable contingent crop. It provides fodder when it is scarce. So, a field experiment was planned with the objective to evaluate the effect of foliar spray of nutrients on growth and productivity of spring fodder maize under saline ecosystem.

MATERIALS AND METHODS

A field experiment was conducted during spring 2023 and 2024 at farmers' field in district Jhajjar, Haryana (India) to evaluate the effect of foliar application of $ZnSO_4$ and NPK on growth and yield of fodder maize (Table 2). The experiment was conducted in randomized block design with three replications. The mean monthly maximum temperature, mean monthly minimum temperature, total rainfall during the crop period were 35.8 and 41.2 ºC, 11.5 and 11.0 ºC and 346.6 and 17.8 mm, respectively, during 2023 and 2024 (Fig. 1). The soil analysis before starting of the experiment in 2023 showed that soil was loam in texture with pH 7.80, medium in OC (0.42%), low in available P (8.00 kg/ha), medium in available K (299 kg/ha) (Table 1). The soil was deficient in zinc (0.46 ppm). The foliar nutrients were sprayed at 40-45 DAS using 500 l/ha water. The sowing of spring fodder maize was done on 15th March 2023 and on 7th March 2024. All recommended package and practices of CCS Haryana Agricultural University for spring maize were followed during both the years.

TABLE 1

Initial soil properties before start of the experiment

Soil parameters	Value
pH	7.80
EC (dS/m)	2.46
OC (%)	0.42
Available P (kg/ha)	8.00
Available K (kg/ha)	299.00
Soil texture	Loam
Soil micro-nutrients (ppm)	
Fe	5.00
Mn	8.40
Zn	0.46
Cu	2.08

STATISTICAL ANALYSIS

One way analysis of variance (ANOVA) was performed using softwareSAS®9.3 (SAS Institute, 2012) and Tukey's *Honest Significant Difference* was used to compare treatments mean.

RESULTS AND DISCUSSION

In spring planted fodder maize, foliar spray of 0.5% $ZnSO_4$ and NPK (19:19:19) at 45 days after sowing (DAS) significantly improved the plant height, biomass per plant, dry weight per plant and green fodder yield as compared to control (Table 2). The maximum plant height (208 cm), biomass per plant (234 g), dry weight per plant (55.1 g) and green fodder yield (476 q/ha) was recorded with foliar spray of 0.5% $ZnSO_4$ + 3% NPK (19-19-19) at 45 DAS at par with 0.5% $ZnSO_4$ + 2% NPK (19-19-19) and 3% NPK (19-19-19) while significantly higher than control. The green fodder yield with foliar spray of 0.5% $ZnSO_4$ + 3% NPK (19-19-19) was 468 and 484 q/ha, 11 and 13% higher than control during spring 2023 and 2024, respectively (Fig. 2.). On pooled basis, the green fodder yield in this treatment was ~12% higher than control.

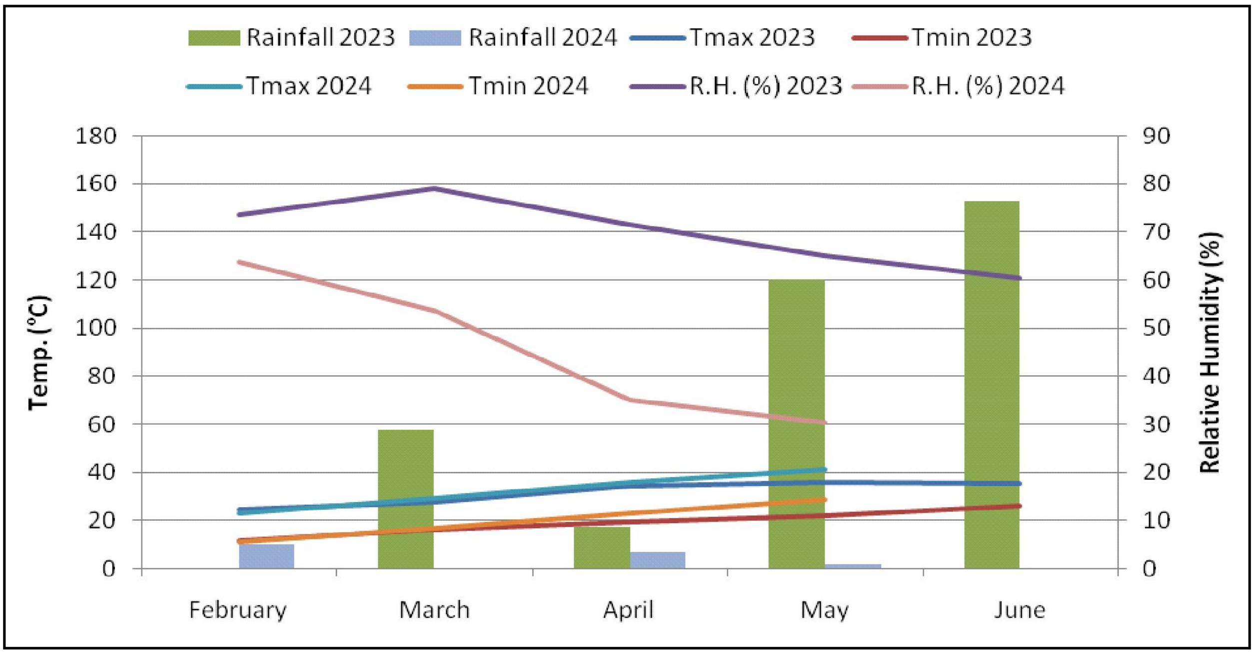

Fig. 1. Weather parameters during the experimental period (2023 & 2024).

TABLE 2

Effect of foliar spray of nutrients on growth and yield of spring fodder maize under saline conditions (Pooled data over two years)

Treatments	Plant height (cm)	Biomass/ plant (g)	Dry weight/ plant (g)	Green fodder yield (q/ha)
Control (water spray)	187	207	46.3	425
Foliar spray of $ZnSO_4$ @ 0.5%	190	214	48.4	435
Foliar spray of NPK (19-19-19) @ 1%	198	220	50.2	448
Foliar spray of NPK (19-19-19) @ 2%	201	224	51.9	460
Foliar spray of NPK (19-19-19) @ 3%	204	227	52.7	466
Foliar spray of $ZnSO_4$ 0.5% + NPK (19-19-19) @ 1%	199	221	50.2	450
Foliar spray of $ZnSO_4$ 0.5% $ZnSO_4$ + NPK (19-19-19) @ 2%	205	232	53.2	472
Foliar spray of $ZnSO_4$ 0.5% $ZnSO_4$ + NPK (19-19-19) @ 3%	208	234	55.1	476
CD (p=0.05)	6.6	8.0	3.4	15.4

*The fertilizers were foliar applied at 45 days after sowing (DAS).

The low nutrient availability in salt-affected soil might be due several reasons. The nutrient imbalance might be due to effect of salinity on nutrient availability, their uptake, transportation in plant system (Grattan and Grieve, 1994). It is also believed that two or more process might work simultaneously which finally governs crop growth and productivity. The soil salinity can also reduce N accumulation in plants (Grattan and Grieve, 1999). So, saline soils may be inherently poor in nutrient availability and further their uptake and accumulation in plants might be reduced. So, foliar application was found to be a feasible option in addition to recommended fertilizer dose to reduced salinity induced stress and improve crop growth and yield. The foliar application of NPK provides nutrients directly to the crop thereby increasing their availability to plants. This also eliminates nutrient fixation in soil. Similar result of higher maize yield with foliar application of NPK under stress condition was reported by Amanullah *et al.* (2014).

The maximum gross return (Rs. 86910/ha), net return (Rs. 23857/ha) and B:C (1.38) were reported with foliar spray of 0.5% $ZnSO_4$ + 3% NPK (19-19-19) closely followed by 0.5% $ZnSO_4$ + 2% NPK (19-19-19). The gross return and net return with foliar spray of 0.5% $ZnSO_4$ + 3% NPK (19-19-19) at 45 DAS was 9370 and 7220 Rs/ha higher than control, respectively. The gross return, net return and B:C with

TABLE 3

Effect of foliar spray of nutrients on economics of spring fodder maize under saline conditions (Pooled data over two years)

Treatments	Gross return (Rs/ha)	Net return (Rs/ha)	B:C
Control (water spray)	77,540	16,637	1.27
Foliar spray of $ZnSO_4$ @ 0.5%	79,370	18,342	1.30
Foliar spray of NPK (19-19-19) @ 1%	81,775	20,197	1.33
Foliar spray of NPK (19-19-19) @ 2%	84,030	21,777	1.35
Foliar spray of NPK (19-19-19) @ 3%	85,069	22,141	1.35
Foliar spray of $ZnSO_4$ 0.5% + NPK (19-19-19) @ 1%	82,130	20,427	1.33
Foliar spray of $ZnSO_4$ 0.5% $ZnSO_4$ + NPK (19-19-19) @ 2%	86,185	23,806	1.38
Foliar spray of $ZnSO_4$ 0.5% $ZnSO_4$ + NPK (19-19-19) @ 3%	86,910	23,857	1.38

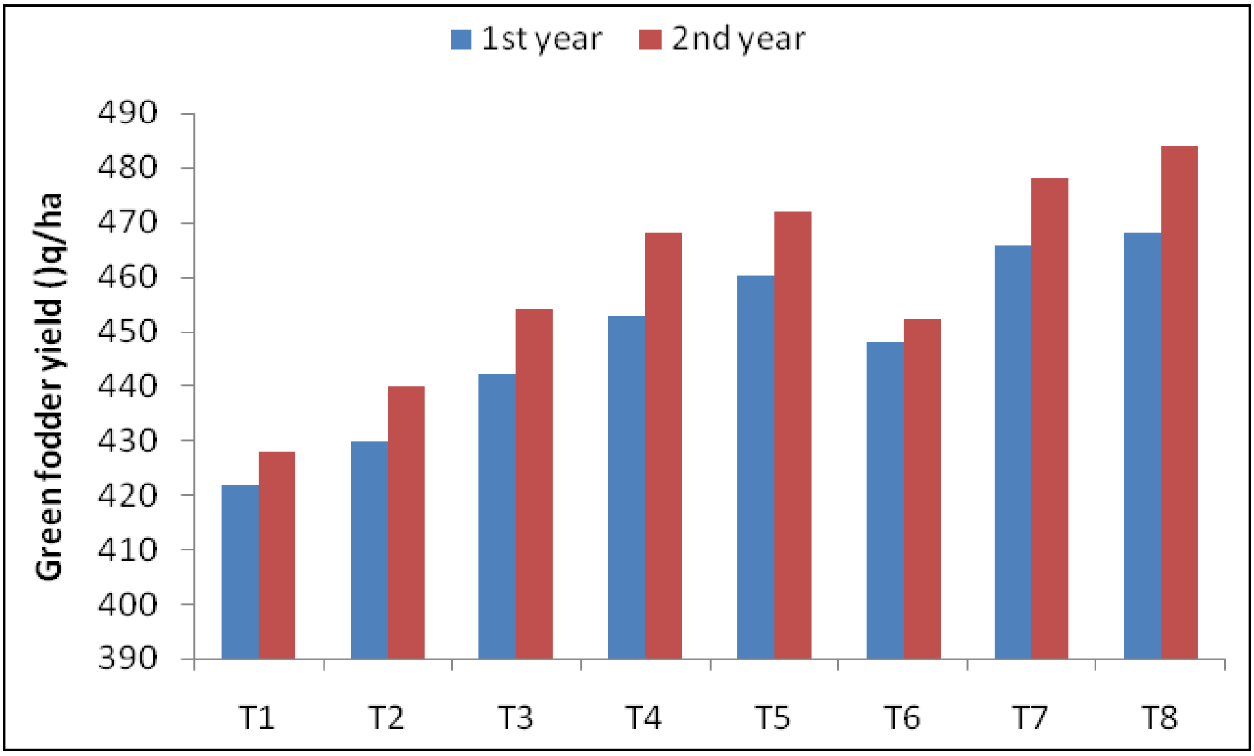

Fig. 2. Effect of foliar spray of nutrients on green fodder yield spring maize under saline conditions.

foliar spray of 0.5% $ZnSO_4$ + 3% NPK (19-19-19) was due to highest green fodder yield without substantial increase in cost of cultivation as compared to control treatment.

CONCLUSION

In spring fodder maize, foliar application of 0.5 % $ZnSO_4$ + 3% NPK (19-19-19) at 45 DAS resulted in significantly the highest crop growth and green fodder yield (476 q/ha) at par with foliar application of 0.5 % $ZnSO_4$ + 2% NPK (19-19-19) and 3% NPK (19-19-19). The green fodder yield with foliar application of 0.5 % $ZnSO_4$ + 3% NPK (19-19-19) was 12% higher than control.

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